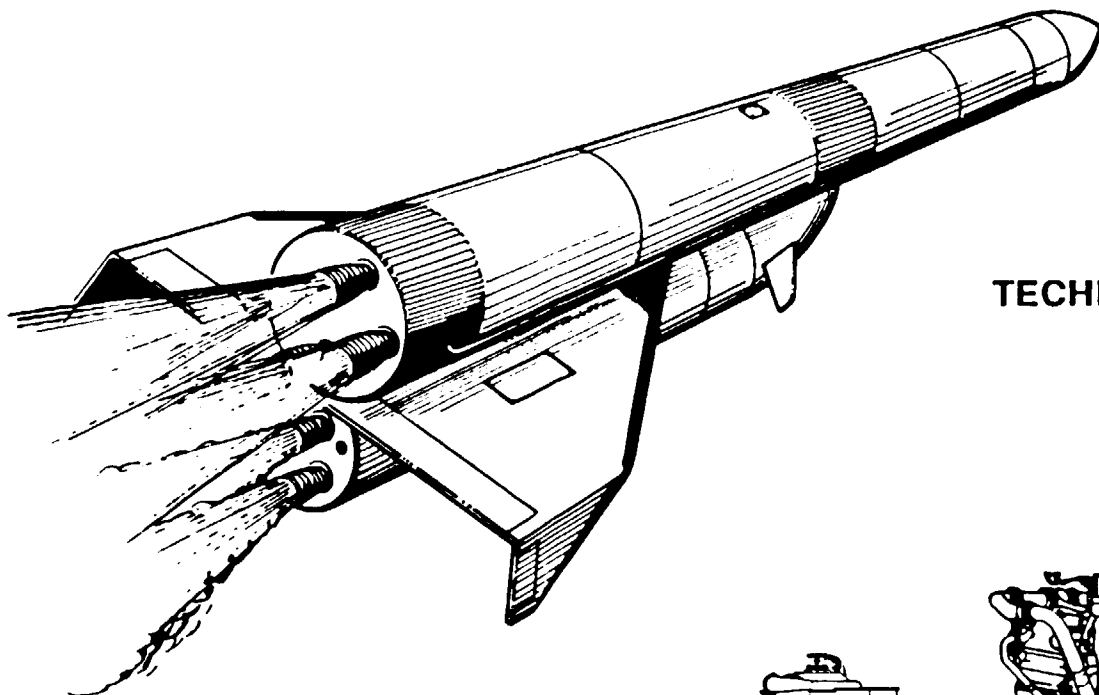
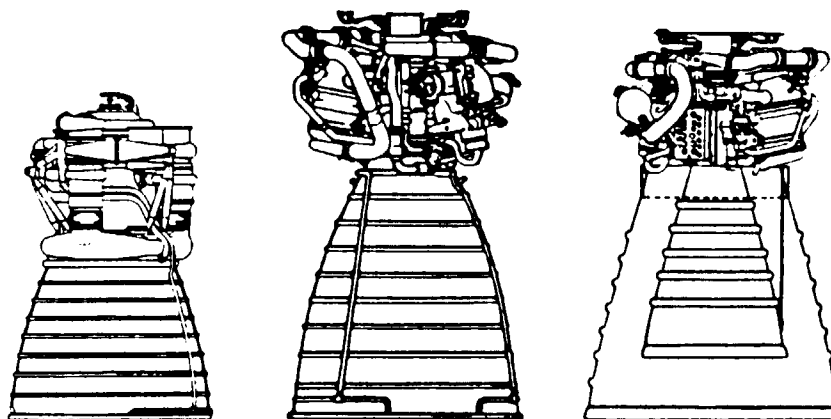


1-5818-8

# NASA EARTH-TO-ORBIT PROPULSION R&T



TECHNOLOGY FOR FUTURE  
NASA MISSIONS



R.J. Richmond  
NASA/MSFC  
Sept. 13, 1988

N89-11769

10-4786  
11/8



## **PURPOSE:**

- o PROVIDE A VALIDATED TECHNOLOGY BASE TO SUPPORT A RANGE OF PROPULSION SYSTEM OPTIONS FOR MINIMUM LIFE CYCLE COST FUTURE SPACE TRANSPORTATION SYSTEMS
- o MAINTAIN AND ENHANCE U.S. LEADERSHIP IN SPACE TRANSPORTATION

## **IMPLEMENTATION:**

- o EARTH-TO-ORBIT PROPULSION R&T IS COMPOSED OF THREE PROGRAM ELEMENTS

### **R &T BASE PROGRAM**

- Fundamental Processes
- New Concepts
- Far Term

### **CSTI**

- o EARTH-TO-ORBIT PROPULSION
  - Oxygen/Hydrogen
  - Oxygen/Hydrocarbon
- o BOOSTER TECHNOLOGY
  - Pressure-Fed Liquids
  - Hybrids



S&E Directorate/R&T Office

## ***EARTH-TO-ORBIT PROPULSION***



Marshall Space Flight Center

---

### **BASE R&T PROGRAM**

#### **OBJECTIVE:**

- EXPAND FUNDAMENTAL KNOWLEDGE AND UNDERSTANDING OF ROCKET ENGINE PROCESSES AND PRINCIPLES
- EXPLORE AND DEFINE ADVANCED TECHNOLOGIES APPLICABLE TO EARTH-TO-ORBIT PROPULSION

#### **JUSTIFICATION:**

- APPLICATION OF NEW CONCEPTS AND IMPROVED UNDERSTANDING OF THE FUNDAMENTALS HOLDS THE POTENTIAL FOR MAJOR ADVANCEMENTS IN ETO PROPULSION

#### **SIGNIFICANCE:**

- WILL ENABLE THE DEVELOPMENT OF FUTURE LAUNCH VEHICLES WITH FAR GREATER PAYLOAD DELIVERY CAPABILITY AT GREATLY REDUCED COST



S&E Directorate/R&T Office

## ***EARTH-TO-ORBIT PROPULSION***



Marshall Space Flight Center

---

### **BASE R&T PROGRAM**

#### **PROGRAM CONTENT:**

- o **FUNDAMENTALS OF COMBUSTION AND FLUID FLOW PROCESSES**
- o **VERY HIGH MIXTURE RATIO COMBUSTORS**
- o **METALLIZED GELLED PROPELLANTS**
- o **APPLICATIONS OF SUPERCONDUCTIVITY**



---

**CSTI EARTH-TO-ORBIT**

**OBJECTIVE:**

- o PROVIDE AN EXPANDED VALIDATED TECHNOLOGY BASE FOR ADVANCED OXYGEN/HYDROGEN AND OXYGEN HYDROCARBON ETO PROPULSION SYSTEMS

**JUSTIFICATION:**

- o INCREASED BENEFITS TO SPACE TRANSPORTATION SYSTEMS THROUGH ADVANCEMENTS IN ETO PROPULSION SYSTEMS
  - PERFORMANCE
  - SERVICE LIFE
  - AUTOMATED OPERATIONS AND DIAGNOSTICS

**SIGNIFICANCE:**

- o WILL ENABLE A RANGE OF PROPULSION SYSTEM OPTIONS FOR MINIMIZING OVERALL SPACE TRANSPORTATION COSTS

## NASA CSTI EARTH-TO-ORBIT PROPULSION R&T PROGRAM

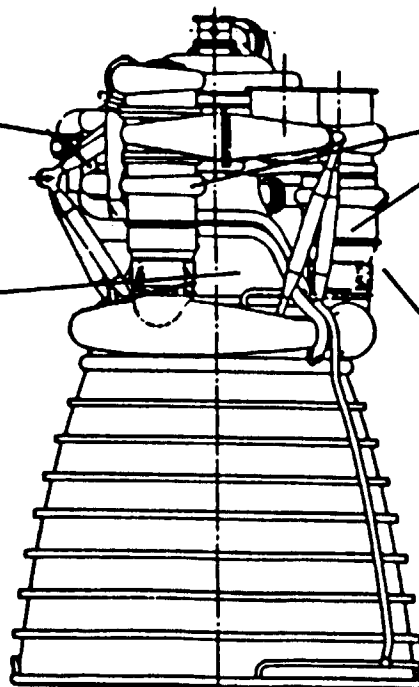
### TECHNOLOGY THRUSTS

#### PREBURNER/GAS GEN

- UNIFORM TEMPERATURE TURBINE DRIVE GAS
- CARBON DEPOSITION

#### THRUST CHAMBER

- COMBUSTION EFFICIENCY
- COMBUSTION STABILITY
- PERFORMANCE PREDICTION
- CARBON DEPOSITION
- THERMAL BARRIER COATINGS
- FUEL COKING
- FUEL COOLANT/CHAMBER LINER COMPATIBILITY
- LOX COOLING
- COOLING PASSAGE GEOMETRY OPTIMIZATION
- TRANSLATING NOZZLE



#### TURBOMACHINERY

- BEARING DURABILITY
- ROTOR DYNAMICS
- AEROTHERMO LOADS
- COOLED TURBINES
- TURBINE BLADE DURABILITY
- HYDROGEN EMBRITTLEMENT
- TURBINE & PUMP SECTION EFFICIENCY

#### CONTROLS & SYSTEM MONITORING

- ADVANCED SENSORS
- DIAGNOSTIC TECHNIQUES
- CONTROL STRATEGY



S&E Directorate/R&T Office

## ***EARTH-TO-ORBIT PROPULSION***



Marshall Space Flight Center

---

### **CSTI EARTH-TO-ORBIT** **Program Content**

#### **o ANALYTICAL/EMPIRICAL MODELS**

#### **PERFORMANCE AND LIFE PREDICTION**

- Flow Process Codes
- Combustion Codes
- Heat Transfer and Cooling
- Loads Definition
- Materials Behavior
- Structural Response
- Fatigue and Fracture

#### **o ADVANCED COMPONENT TECHNOLOGY**

#### **METHODOLOGIES AND PROCESSES**

- Bearings
- Seals
- Turbine Blades
- Active Dampers
- Materials
- Coatings
- Manufacturing



---

**CSTI EARTH-TO-ORBIT**  
**Program Content (Cont'd)**

**o INSTRUMENTATION**

**SYSTEM MONITORING AND CONTROL**

- Performance Analysis
- Engine Control
- Safety Monitoring
- Condition Monitoring

**o ENGINEERING TESTING**

**SUBCOMPONENT VALIDATION**

- Models and Codes
- Materials
- Processes
- Instruments

**o SUBSYSTEM/TESTBED ENGINE  
TESTING**

**TRUE ROCKET OPERATING ENVIRONMENT  
VERIFICATION**

- Steady State
- Transient
- All Influences and Interactions Present





S&E Directorate/R&T Office

## ***EARTH-TO-ORBIT PROPULSION***



Marshall Space Flight Center

---

### **CSTI EARTH-TO-ORBIT** **MAJOR DELIVERABLES**

#### **o VALIDATED ANALYTICAL CODES:**

- Enhanced Structural Dynamics Codes for Internal Force Definition**
- Enhanced Life Prediction Codes Based on Fracture, Fatigue**
- Enhanced Rotordynamics Codes**
- Enhanced Engine Performance Prediction/Combustion Codes**

#### **o ADVANCED DESIGN METHODOLOGY FOR:**

- High Efficiency, Long Life Turbines, Pumps, Bearings, and Ducts**
- Combustor Stability and Cooling**
- Turbomachinery Stability**
- Safety Monitoring, Condition Monitoring, and Control Systems**



---

**CSTI BOOSTER PROPUSLION**

**OBJECTIVE:**

- o DEVELOP THE VALIDATED DATA BASE AND DESIGN METHODOLOGY FOR ADVANCED BOOSTER PROPULSION SYSTEMS
  - HIGH THRUST
  - OXYGEN/HYDROCARBON PRESSURE-FED LIQUIDS
  - OXYGEN/SOLID FUEL HYBRIDS

**JUSTIFICATION:**

- o PRESSURE-FED AND HYBRID PROPULSION HAVE INCREASED PERFORMANCE, THRUST TERMINATION, AND THRUST TAILORING CHARACTERISTICS

**SIGNIFICANCE:**

- o WILL ENABLE ALTERNATIVE OPTIONS TO THE SOLID ROCKET BOOSTERS FOR FUTURE SPACE SHUTTLE AND OTHER LAUNCH VEHICLE APPLICATIONS THAT OFFER SAFE-ABORT AND INCREASED PAYLOAD CAPABILITY



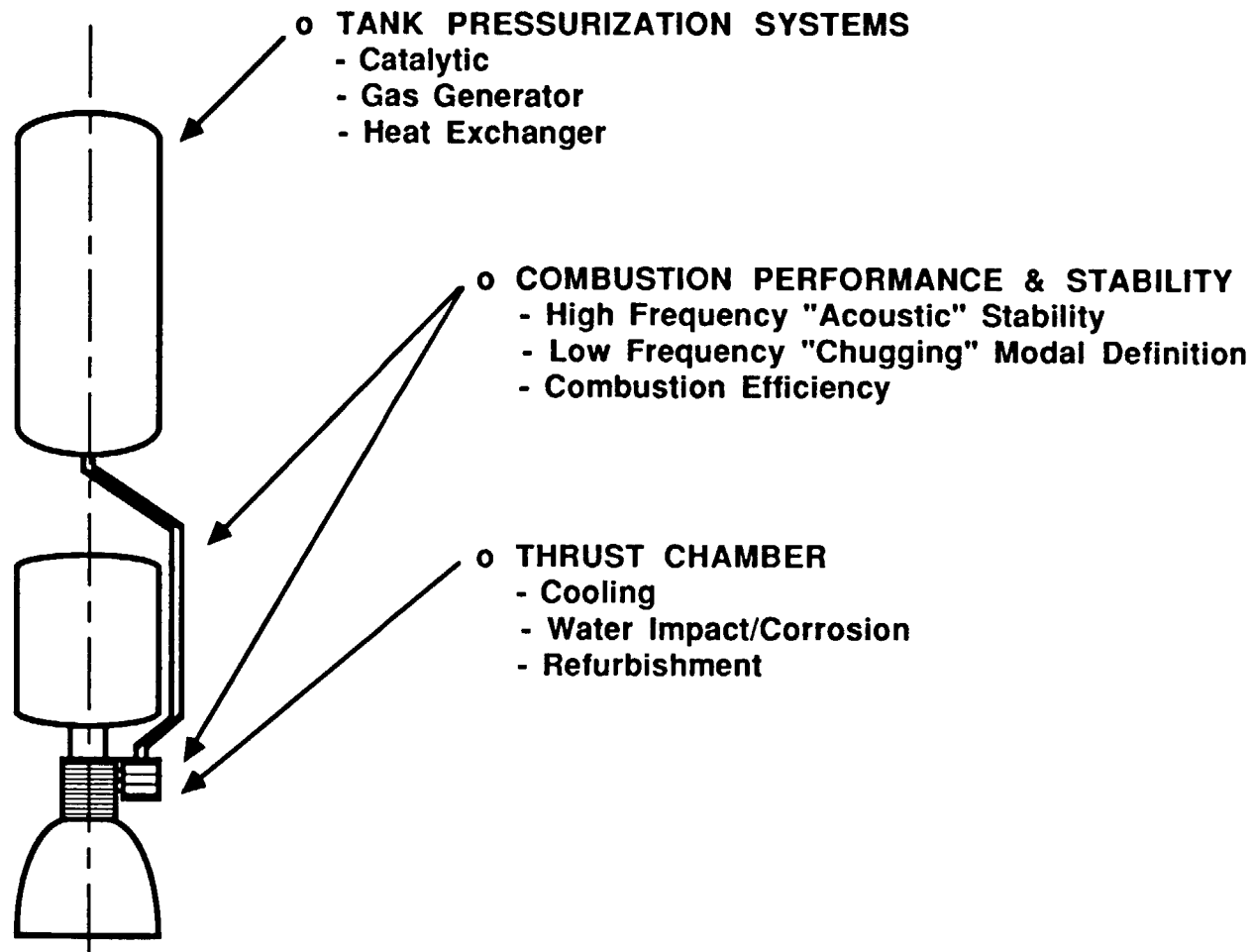
S&E Directorate/R&T Office

## BOOSTER TECHNOLOGY



Marshall Space Flight Center

### PRESSURE-FED LIQUIDS - TECHNOLOGY ISSUES





---

**CSTI BOOSTER PROPULSION**  
**PROGRAM CONTENT**

**o PRESSURE-FED LIQUIDS**

- ANALYTICAL MODELS
  - Low Pressure, Large Scale Combustors
  - Tank Pressurization
- LABORATORY, SMALL SCALE TESTING FOR CODE VALIDATION
- LARGE SCALE COMPONENT TESTING FOR DESIGN METHODOLOGY VERIFICATION

**o HYBRIDS**

- ANALYTICAL MODELS
  - Combustion Processes
  - Propellant Feed System
- LABORATORY, SMALL SCALE TESTING FOR CODE VALIDATION
- SUBSCALE MOTOR TESTING FOR DESIGN METHODOLOGY VERIFICATION



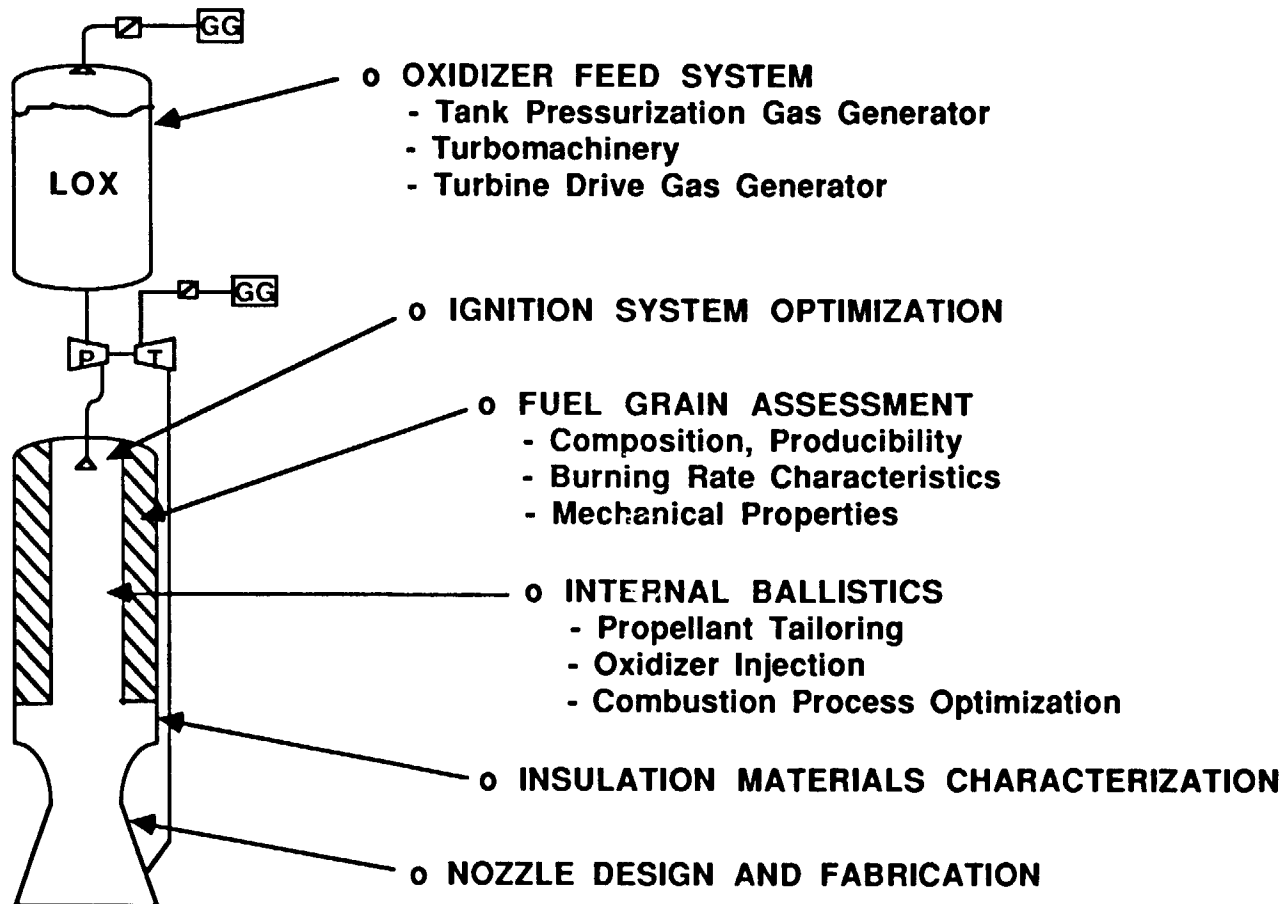
S&E Directorate/R&T Office

## BOOSTER TECHNOLOGY



Marshall Space Flight Center

### HYBRIDS - TECHNOLOGY ISSUES





---

**CSTI BOOSTER PROPULSION**  
**MAJOR DELIVERABLES**

**o VALIDATED ANALYTICAL CODES:**

- Low to Moderate Pressure, Bipropellant Combustion Processes
- Hybrid Combustion Processes
- High and Low Mixture Ratio Combustion for Tank Pressurization
- In-Tank Condensible Predictions

**o ADVANCED DESIGN METHODOLOGY FOR:**

- Pressure-Fed Combustor Design with High Performance, Stable Combustion, Minimum Pressure Drop Cooling, and Minimum Weight Ablative
- Hybrid Solid Fuel Grain Design, Oxidizer Injection and Ignition Systems
- High and Low Mixture Ratio Combustors
- High and Low Mixture Ratio Ignition Systems